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Morphology and egg measurements of seabirds breeding on Great Salvage Island, North Atlantic

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Five species of Procellariiformes breed on Great Salvage Island in the North Atlantic Ocean: Cory's Shearwater *Calonectris diomedea borealis,* Little Shearwater *Puffinus assimilis baroli,* Bulwer's Petrel *Bulweria bulwerii,* Madeiran Storm Petrel *Oceanodroma castro* and White-faced Storm Petrel *Pelagodroma marina hypoleuca.* Between 17 June and 11 July 1983, while studying the vocal behaviour of these birds (James & Robertson 1985a, 1985b, 1985c) we made observations on their body measurements, egg measurements and incubation spells.

The breeding biology and population status of **Cory's Shearwater** on Great Salvage Island have been studied by Jouanin & Roux (1966), Zino (1971), Jouanin *et al.* (1977), Jouanin *et al.* (1980), and Mougin & Stahl (1982). The present population is about 12–15,000 breeding birds plus 15–20,000 non-breeders (Mougin & Stahl 1982). Nesting is in small caves and crevices in rock walls around the slopes of the island, and in man-made rock shelters and walls on the plateau. During our visit, egg-laying had just finished and no eggs had hatched.

Little Shearwaters were studied on Great Salvage Island during the non-breeding season (Jouanin 1964). At the start of our visit the last nestlings were fledging, but during a period of low moonlight intensity between 1 and 10 July many Little Shearwater pairs revisited their nesting grounds, which Jouanin (1964) termed a "protogamic return".

Lockley (1952) and Jouanin *et al.* (1979) studied **Bulwer's Petrel** in the Portuguese islands of the subtropical North Atlantic. It was nesting in crevices in old rock walls, and was completing egg-laying at the start of our visit; no eggs had hatched by the time we left.

The breeding of **Madeiran Storm Petrels** has been described briefly by Bannerman (1914, 1963) from the North Atlantic, but in detail by Allan (1962) on Ascension Island, South Atlantic, and by Harris (1969) on the Galapagos Islands, Pacific Ocean. At the start of our visit, egg-laying was in progress, mostly in nests in crevices in old rock walls, but a few in burrows in sandy soil on the plateau.

White-faced Storm Petrel breeding has been described briefly on the Salvages by Jouanin & Roux (1965), but in detail by Richdale (1943–44) in New Zealand. We found these petrels nesting exclusively in burrows in sandy ground on the plateau. Most pairs had well grown young, but a few were still incubating eggs.

In the limited time available, we collected information on the breeding biology of these species, and compare it with some of the previous studies.

Study area

Great Salvage Island (30°09′N, 15°52′W) is the largest of an archipelago of small uninhabited islands in the subtropical North Atlantic. It lies *c.* 250 km south of Madeira and 150 km north of the Canary Islands, and has an area of about 250 ha. It is volcanic in origin and consists largely of a plateau *c.* 100 m above sea level surrounded by steep slopes and cliffs. Two small hills rise from the plateau, the highest reaching 154 m. During our stay, the island was virtually devoid of plant-life after a prolonged dry spell. The vegetation consisted of isolated clumps of *Nicotiana glauca,* large patches of low-growing heath *Suaeda vera* in the north, and ice plants *Mesembrianthemum crystallinum* and *M. nodiflorum.* On the plateau and on some of the gentler slopes from the plateau in the southwest part of the island, cultivation was attempted last century, leaving a series of dilapidated rock-walls which provide excellent nesting crevices for all species except White-faced Storm Petrels. There was no visible sign of the extensive guano digging on the plateau described by Lockley (1942) from a visit in 1939. Our main study area was on the slopes leading to the plateau in an area of former cultivation near the research station, and there was a subsidiary study area on the northern part of the plateau for work on the White-faced Storm Petrel.

Methods

Crevice nests were located from the vocal activity of breeding birds, often in response to a tape of the species call (James & Robertson 1985c) from a Sony M9 microcassette recorder, or from inspection of potential nest

sites. Because egg-laying was in progress or had just finished for Bulwer's Petrels and Madeiran Storm Petrels, it was possible to sex birds by cloacal inspection (Serventy 1956). Cory's Shearwater and Little Shearwater pairs were sexed by voice (Wink & Ristow 1979, James & Robertson 1985a) and subsequent discriminant functions using body measurements. White-faced Storm Petrel pairs could not be sexed with certainty because they were virtually silent at the colony, but pairs were caught at nest sites as they fed their chicks and these birds were subsequently sexed from body measurements.

With the exception of Cory's Shearwaters, which were marked on the forehead with indelible ink, all birds handled were banded with a numbered metal ring supplied by the Portuguese Ringing Scheme. The birds were weighed (gm) and up to 5 measurements (mm) taken:

bill length—chord of the exposed culmen dorsally from the tip to the start of the feathering;
bill depth—depth of the bill at the base of the exposed culmen;
tarsus—diagonally from the mid-point of the joint between the tibia and metatarsus to the junction of the metatarsus and middle toe;
wing—chord of the closed but unstraightened wing from the wrist joint to the tip of the longest primary;
tail—ventrally from the base to the tip of the longest feather of the closed tail.

Linear measurements were taken with dial calipers or a metal ruler, and weights with Pesola spring balances. Eggs were measured with dial calipers to the nearest 0.1 mm and weighed to the nearest 0.1 g with Pesola spring balances.

RESULTS

Bird measurements

CORY'S SHEARWATER *Calonectris diomedea borealis*

Thirty-nine breeding pairs were measured (Table 1). For each of the 5 measurements, males were significantly larger than females, as found in the nominate subspecies *diomedea* in the Mediterranean (Wink & Ristow 1979), especially regarding weight and bill depth. There were, however, significant differences between these 2 subspecies (*borealis* and *diomedea*) (Table 2); the mean weight of *diomedea* was only 62% of that of *borealis*, and indeed *borealis* females on Great Salvage Island were considerably larger even than male *diomedea* of the Mediterranean for all measurements; male *diomedea*, for instance, were only 72% of the weight of female *borealis*.

LITTLE SHEARWATER *Puffinus assimilis baroli*

Cramp & Simmons (1977) suggest that males have longer bills than females in *baroli*, but the data from Great Salvage Island (Table 3) do not support this; however, males had significantly deeper bills, longer tarsi and were heavier than females. Most Little Shearwaters that we handled were moulting and so our sample sizes for wing and tail lengths were too small for the sexes to be compared. These are the first weight data for

TABLE 1
Measurements of adult Cory's Shearwaters *Calonectris diomedea borealis* on Great Salvage Island

		Mean	s.d.	Range	n	Paired t test	p
Bill length	♂	58.78	1.98	54.5–61.7	39	7.07	<0.001
	♀	55.67	1.91	52.0–59.9	39		
Bill depth	♂	22.59	0.77	21.0–24.1	39	14.26	<0.001
	♀	20.40	0.57	19.3–21.6	39		
Tarsus	♂	60.25	1.19	57.6–62.7	39	7.24	<0.001
	♀	58.12	1.40	54.7–61.1	39		
Wing	♂	371.1	6.0	357–386	39	5.40	<0.001
	♀	363.0	7.1	343–375	39		
Weight	♂	955.6	74.7	775–1095	39	8.58	<0.001
	♀	817.3	67.4	690–930	39		

TABLE 2
Comparison of body measurements of *Calonectris diomedea borealis* on Great Salvage Island, Atlantic Ocean with *C. d. diomedea* on islands in the Aegean Sea, Mediterranean (Wink & Ristow 1979)

	Male		**Female**	
	borealis	*diomedea*	*borealis*	*diomedea*
Bill length	58.8±2.0	49.5±1.4	55.7±1.9	46.2±1.2
Bill depth	22.6±0.8	18.6±0.8	20.4±0.6	16.6±0.5
Tarsus	60.3±1.2	53.4±1.7	58.1±1.4	52.0±1.2
Wing	371.1±6.0	341.8±7.6	363.0±7.1	331.1±8.4
Weight	955.6±74.7	585.8±58.7	817.3±67.4	514.1±64.0

North Atlantic Little Shearwaters, and indicate that *P. a. baroli* is lighter than *P. a. elegans* of Gough Island, South Atlantic, which averaged 225.6 g (Swales 1965).

BULWER'S PETREL *Bulweria bulwerii*

Morphometric data for 52 birds of each sex, including 48 pairs, are given in Table 4. Males were significantly larger than females for all measurements except wing length. Bill depth gave the best differentiation between the sexes with only 3 females out of 48 (6%) having a deeper bill than their partner, and 2 (4%) the same depth. Jouanin *et al.* (1979) gave data for a sample (mixed sexes) from Great Salvage Island, and failed to find any significant differences between the sexes perhaps because of increased variance caused by combining measurements of birds from many different breeding populations, in both the Atlantic and Pacific Oceans. For male tarsus lengths, for example, the variance of their sample was significantly greater than ours ($F_{21,51}=2.06$, $p<0.05$). Our results were similar to those given by Cramp & Simmons (1977), except that

TABLE 3
Measurements of adult Little Shearwaters *Puffinus assimilis baroli* on Great Salvage Island

		Mean	s.d.	Range	n	Paired t test	p
Bill length	♂	25.28	0.94	23.7–26.7	24	0.62	ns
	♀	25.13	0.66	23.7–26.3	17		
Bill depth	♂	9.20	0.39	8.4–9.8	24	3.82	<0.001
	♀	8.84	0.21	8.5–9.2	17		
Tarsus	♂	36.80	1.06	34.7–39.0	24	2.49	<0.05
	♀	36.11	0.73	34.4–37.0	17		
Wing	♂	177.5	2.5	174–180	4		
	♀	178.6	6.4	175–186	3		
Tail	♂	76.3	2.5	74–79	3		
	♀	71.4	5.8	63–78	5		
Weight	♂	160.3	11.9	142–189	24	2.97	<0.001
	♀	151.2	7.8	139–166	17		

Notes: (a) Most birds were moulting wing and tail feathers and although all birds were measured, only those that had finished moult are presented here. Sample sizes were too small to compare the sexes.
(b) From 14 pairs measured, and compared with paired t test, similar results were obtained, with bill depth being the most dimorphic ($t=8.54$, <0.001); tarsus ($t=3.42$, <0.01) and weight ($t=2.85$, <0.05) were less so.

TABLE 4
Measurements of adult Bulwer's Petrels *Bulweria bulwerii* on Great Salvage Island

		Mean	s.d.	Range	n	Paired t test	p
Bill length	♂	21.64	0.57	20.6–23.0	52	4.20	<0.001
	♀	21.19	0.53	20.1–22.3	52		
Bill depth	♂	9.89	0.36	8.7–10.5	52	9.51	<0.001
	♀	9.19	0.40	8.0–9.9	52		
Tarsus	♂	27.69	0.77	25.7–29.4	52	2.66	<0.01
	♀	27.28	0.80	25.8–29.4	52		
Wing	♂	198.1	4.1	190–208	52	0.36	ns
	♀	197.8	3.6	190–204	52		
Weight	♂	107.1	11.8	87–131	52	3.33	<0.01
	♀	99.9	10.0	75–116	52		

Note. A female weighed only 73 g after an incubation spell of at least 12 days, but the data presented above are the weights of birds at first encounter. (See text on weight loss of incubating birds.)

females on Great Salvage Island were significantly heavier than 5 weighed on Deserta Grande ($t=2.44$, $p<0.01$). (For other measurements of *B. bulwerii* see Zonfrillo in this issue (*Bull. Brit. Orn. Cl.* 108(2): 72).

MADEIRAN STORM PETREL *Oceanodroma castro*

Table 5 gives measurements of 37 breeding males and 35 breeding females, including 31 known pairs. Females had significantly longer

TABLE 5
Measurements of adult Madeiran Storm Petrels *Oceanodroma castro* on Great Salvage Island

		Mean	s.d.	Range	n	Paired t test	p
Bill length	♂	14.73	0.66	13.4–16.1	37	0.58	ns
	♀	14.65	0.56	13.7–15.8	35		
Tarsus	♂	23.08	0.67	21.3–24.0	37	0.01	ns
	♀	23.08	0.64	22.0–24.3	35		
Wing length	♂	149.5	3.9	141–158	37	−3.04	<0.01
	♀	152.1	3.2	146–158	35		
Tail length	♂	65.7	1.7	62–69	37	−1.02	ns
	♀	66.2	2.4	62–71	35		
Weight	♂	44.8	4.3	36–55	37	−0.85	ns
	♀	45.6	3.7	35–51	35		

TABLE 6
Measurements of adult White-faced Storm Petrels *Pelagodroma marina hypoleuca* on Great Salvage Island

	Mean	s.d.	Range	n
Bill length	18.20	0.55	16.9–19.7	54
Tarsus	44.50	0.95	41.4–46.1	54
Wing	159.4	3.97	150–168	54
Tail	70.6	2.77	64–76	54
Weight	53.50	6.75	39–69	54

wings than males, but there were no significant differences in other measurements. Cramp & Simmons (1977), from an examination of a small sample of museum specimens collected in the North Atlantic, had found that females had significantly longer tails as well as wings; but from our findings tail length is not a reliable character to use in sexing live birds.

WHITE-FACED STORM PETREL *Pelagodroma marina hypoleuca*

Table 6 gives measurements of 54 birds, including 17 pairs, caught at their breeding colony as they returned at night to feed their chicks. No morphometric data exist for White-faced Storm Petrels to indicate if they show the reversed sexual dimorphism which is usual for the Hydrobatidae. We compared the difference in wing length and tail length between members of each of the 17 known pairs, with all possible pairings of the 34 birds involved. If White-faced Storm Petrels were not sexually dimorphic, then the mean difference within pairs would be the same as the mean difference of the population unless they were mating assortatively. The difference in wing lengths within pairs was 6.5 ± 3.3 mm (median 7 mm, n=17) compared with 5.0 ± 3.6 mm (median 4 mm, n=561) for the population (Mann-Whitney U test, $p < 0.05$); while difference in tail lengths within pairs was 3.4 ± 2.4 mm (median 3 mm, n=17) compared with 2.8 ± 2.4 mm (median 2 mm n=561) (Mann-Whitney U

TABLE 7
Egg measurements of Cory's Shearwater *Calonectris diomedea borealis*, Bulwer's Petrel *Bulweria bulwerii* and Madeiran Storm Petrel *Oceanodroma castro* on Great Salvage Island

	Cory's Shearwater	Bulwer's Petrel	Madeiran Storm Petrel
Sample size	51	56	32
Length (mm)	75.55±2.98	42.01±1.34	32.49±1.11
Width (mm)	49.48±1.56	30.59±1.01	24.28±0.89
Initial weight (g)	96.88±6.94	20.73±1.83	10.28±1.14
Wt loss per day (g)	0.304±0.081	0.074±0.020	0.039±0.021
Calculated fresh weight (g)	101.74	21.66	10.57
Fresh weight as % female weight	12%	22%	23%

test, $p=0.26$). The significant result for wing lengths indicates that White-faced Storm Petrels are sexually dimorphic for that measurement, and probably for tail length also since the 2 measurements were positively correlated ($r=0.62$, $p<0.001$); but whether females are larger or smaller than males cannot be stated.

Egg measurements and weight loss

Table 7 gives the size of eggs of Cory's Shearwater, Bulwer's Petrel and Madeiran Storm Petrel. Because most birds had finished egg-laying we could obtain very few fresh weights, but we recorded initial weights and those taken up to 22 days later to study the rate of weight loss. We calculated approximate fresh weights from the formula: $w=klb^2$ (Hoyt 1979) where l=length and b=breadth. using k=0.55 from Zino (1971) and our measurements of a few fresh eggs. The calculated fresh egg weight averaged 12% of the female's weight for Cory's Shearwater, 22% for Bulwer's Petrel and 23% for the Madeiran Storm Petrel.

Incubation spells and body weight loss

Bulweria bulwerii. The longest incubation spells that we recorded were 2 of at least 13 days each. Female E001415 weighed 114 g on 19 June and 82 g on 1 July, but had changed with her mate by 3 July. Female E001451 weighed 106 g on 21 June, 77 g on 1 July, 73 g on 3 July and had been replaced by her mate on 4 July. At least 5 other birds had incubation spells of 10 or more days. The usual incubation spell seemed to last at least a week. Lockley (1952) recorded that one bird on Deserta Grande incubated for at least 5 days, incorrectly quoted by Cramp & Simmons (1977) as "spells of 1–5 days".

Of 21 birds re-weighed after at least 7 days during their incubation spell, their mean weight loss from first weighing was 2.50±0.50 g per day (range 1.38–3.29) or 2.4% of initial weight per day, with no significant difference between males (2.60±0.47, n=9) and females (2.42±0.53, n=12) ($t=0.82$, n.s.). The total weight loss averaged about 20% of initial body weight over an incubation spell of 8–9 days.

Oceanodroma castro. Two birds had incubation spells of at least 6 days and 6 other birds had spells of 5 or more days. Female E001642 weighed 44 g on 6 July and 34 g on 11 July, and male E001665 weighed 50 g and 42 g on the same respective dates. Incubation spells on Great Salvage Island were about similar to the 4–7 days recorded by Harris (1969) on the Galapagos.

For 12 birds that were re-weighed after at least 3 days during an incubation spell, the mean weight loss from first weighing was 1.81 ± 0.35 g per day (range 1.25–2.50) or 4% of initial weight per day, with no significant difference between males (1.79 ± 0.19, $n=6$) and females (1.84 ± 0.47, $n=6$) ($t=-0.2$, n.s.). This daily weight loss was considerably more than the 2.4% per day of Bulwer's Petrels, but the total loss over an incubation spell of 5 days would have been similar at about 20% of initial body weight.

Discussion

Great Salvage Island is one of the most important breeding sites in the North Atlantic for oceanic seabirds, containing populations of Cory's Shearwater, Bulwer's Petrel and Madeiran Storm Petrel which are probably the largest in the area. Of the 5 species of seabirds breeding there, only Cory's Shearwater has been studied in detail. French scientists have studied the population dynamics for over 20 years and Zino (1971) made a detailed study of breeding during parts of 2 seasons. The other 4 species have been largely neglected, even though nests are numerous and accessible. Our results, showing significant mensural differences between known subspecies, probably indicate that there is little genetic interchange between insular breeding populations, even though the feeding ranges of the different North Atlantic populations are likely to overlap extensively. To maintain genetic diversity in these species it is important that more islands are protected as scientific reserves, and managed so as to both remove predators (including man) and to prevent their acccidental or deliberate introduction. Great Salvage Island is probably safe as long as the Portuguese Government and World Wildlife Fund continue to support the presence of wardens during the seabird breeding season, and while regular watches for ground predators are strictly maintained.

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An old record of the Pearly-breasted Cuckoo in North America and a nomenclatural critique

by Richard C. Banks

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The type of *Coccyzus julieni* Lawrence, 1864, from Sombrero Island, West Indies, is a specimen of the species currently known as the Pearly-breasted (or Euler's) Cuckoo *Coccyzus euleri* Cabanis, 1873, of South